The Next 20 Years

Presented by:

Trace Gunsch
Critical Skill Expert - Emerging Technology
US Army Technology Integration Center
USAISEC AMSEL-IE-TI
(520) 533-2860, DSN: 821-2860
gunscht@hqisec.army.mil
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20 Years of the PC

- IBM sold the first PC in 1981. A lot has changed in the 20 years since its arrival

	1981 (A typical $2000 COTS PC)	2001
CPU	4 MHz	1.2 GHz
RAM	640 KB	512 MB
HD	0-10 MB	20 GB
Removable Storage	360 KB floppy	600 MB RW CD
Communications	300 baud modem	256k-8Mbps DSL

1000-fold increase in 20 years – Moore's Law is right on track

The Next 20 Years

	2001	2021
CPU	1.2 GHz	TeraHz
RAM	512 MB	500 GB
HD	20 GB	20 TB
Removable Storage	600 MB RW CD	600 GB Super-DVD
Communications	256k-8Mbps DSL	wireless/fiber to the home at 1 Gbps

"2021 - $2000 buys computing power equivalent to one human brain." (software not included)

–R. Kurzweil, The Age of Spiritual Machines, 1999

20 Years of the PC

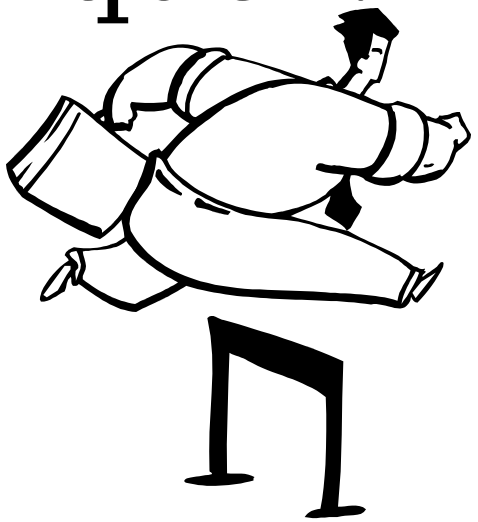
	1981	2001
Interface	command line keyboard	GUI keyboard/mouse/joystick
Display	monochrome Text-only	Millions of colors MPEG-2 video streaming
Output	9-dpi dot-matrix printers	Color laser printing
Audio	PC Speaker	RealAudio radio stations
Killer Application	VisiCalc E-mail	Web Browsing Instant Messaging

The Next 20 Years

	2001	2021
Interface	GUI keyboard/mouse/joystick	speech recognition, eye tracking
Display	Millions of colors MPEG-2 video streaming	Eyeglass displays Virtual Reality (VR)
Output	Color laser printing	3-D "Sculpting"
Audio	RealAudio radio stations	3-D pinpoint audio
Killer Application	Web Browsing Instant Messaging	VR stories/shows "Holodeck in a Headset"

Applications Drive the Network

What's Left to Conquer?

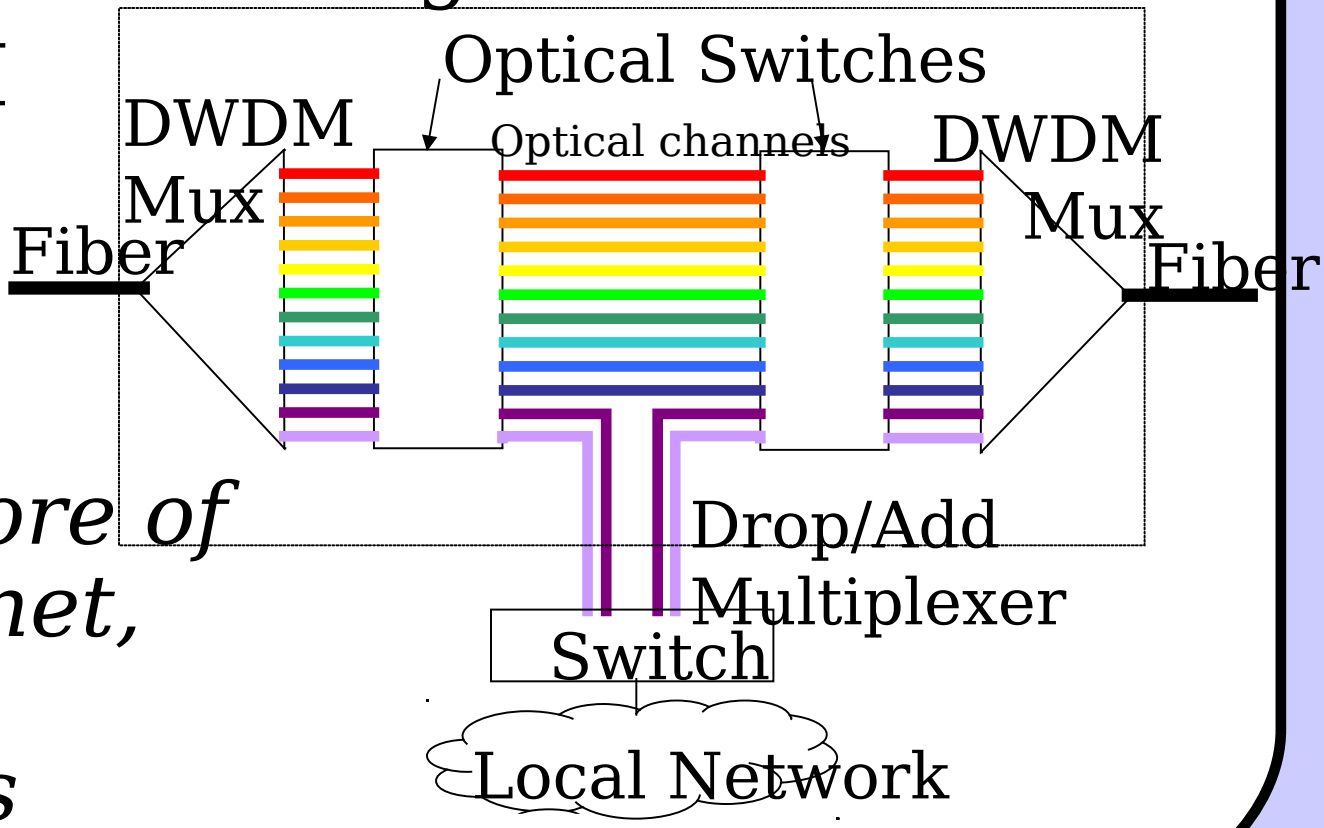


- The WAN
- The "Last Mile"
- The "Wireless World"
- Security
- Productivity/Knowledge Management

Rest of Industry's Efforts go toward Convenience & Entertainment

The WAN

- Optical Switching
- DWDM



"At the core of the Internet, all we will see is light."

P. Chowdhry, PC Week

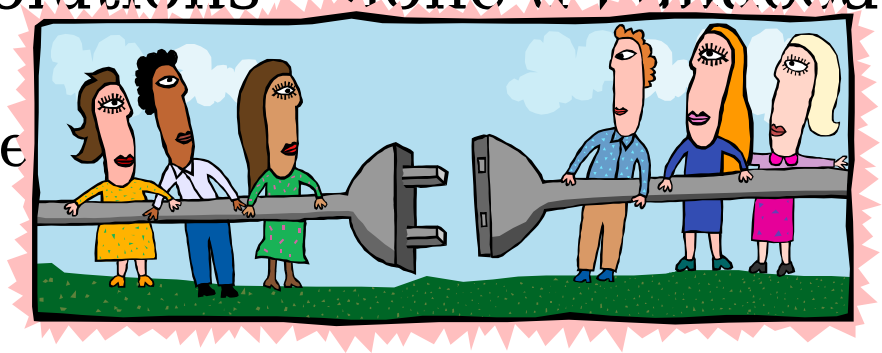
The WAN

	2001	2021
WAN backbone	ATM/SONET	DWDM/Optical Switching
Delays	Milliseconds	Microseconds
Switching	electrons, IP routing	photons/wavelength switching
Quality of Service	DiffServ/MPLS	Priority queuing for rare congestion
Philosophy	"***Use processing to minimize bandwidth***"	"***Use bandwidth to simplify everything else***"*

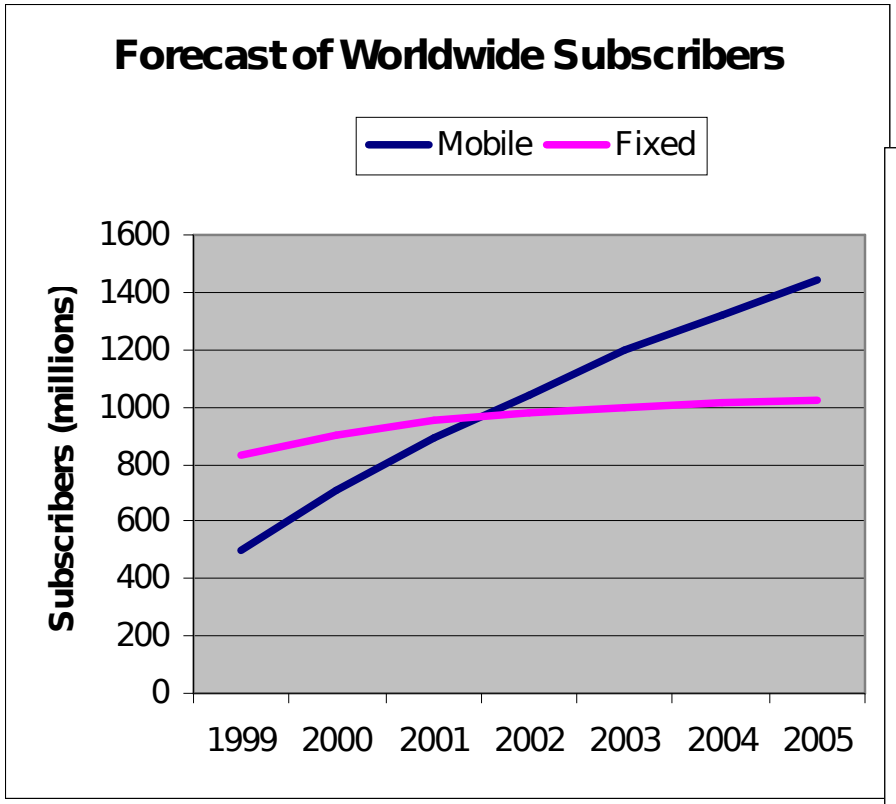
* Gilder, Telecosm

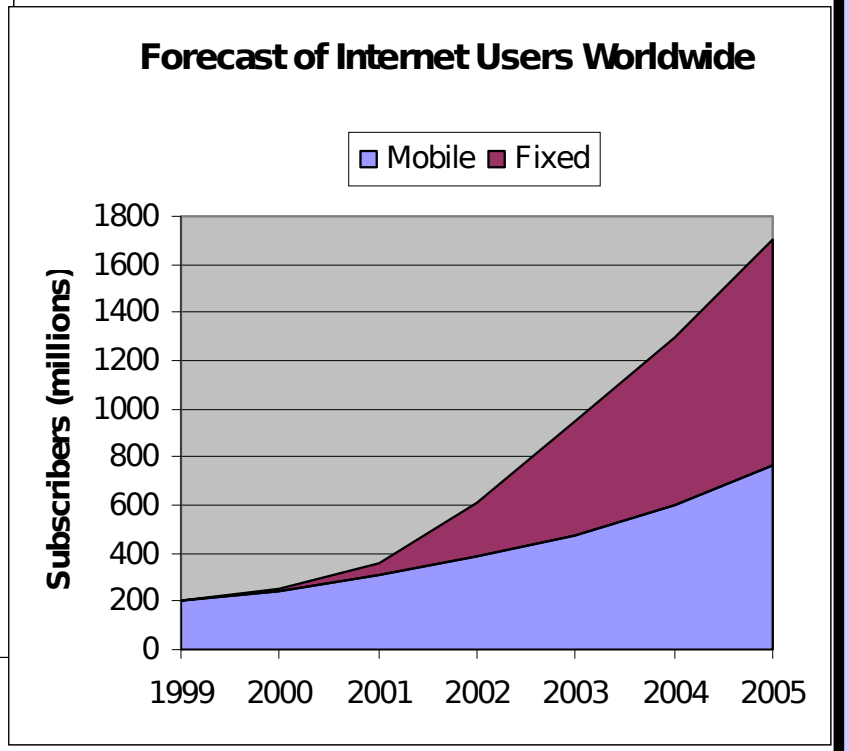
The Last Mile

- Need to get high bandwidth to mobile users and to homes – *the Last Mile Problem*
  - Lots of proposed solutions – none a panacea
    - Cable Modems
    - DSL over phone line
    - Power lines
    - Satellite
    - Wireless
  - Fiber to the home ideal but too expensive
  - Mobile users need high-speed wireless



Wireless Is Exploding

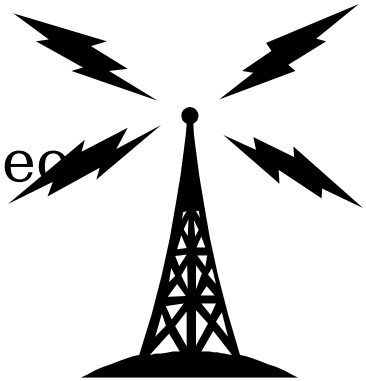




Source: International Data Corporation

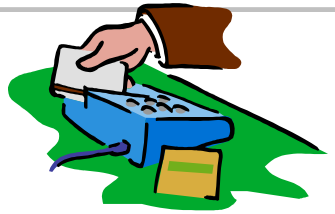
Wireless Access Technologies

- Cellular phone and PCS evolving to 3G (Third Generation)
  - Data rates of up to 2 Mbps
  - Good for voice, data and limited video
- LAN standards emerging
  - 802.11: Compatible with Ethernet
  - 802.15/Bluetooth: Seamless, automatic communication between cell phones, PDAs, PCs, laptops, etc.
- Wireless WAN options/Free Space Optics
  - e.g. TeraBeam, 1Gbps shared, ≤ 96 users



Security

	2001	2021
Strategy	Firewall + IDS + ACL	Defense in Depth
Administration	Reactive, software patching	Proactive, preemptive
Security logs	Auto-compiled, analyzed by administrator	Auto-correlation. AI tools identify patterns
Access Control	Passwords, smart cards	Biometrics



Applications

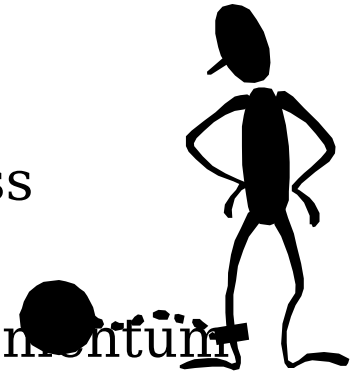
- PC processing/bus speed less than channel capacity

	2001	2021
Interface	Office Suite	Browser-based
Data Mining	Text-based Search tools database queries	Search of Audio/video contect searches
Application potential	Restricted by network	Restricted by Processor/Bus

Applications

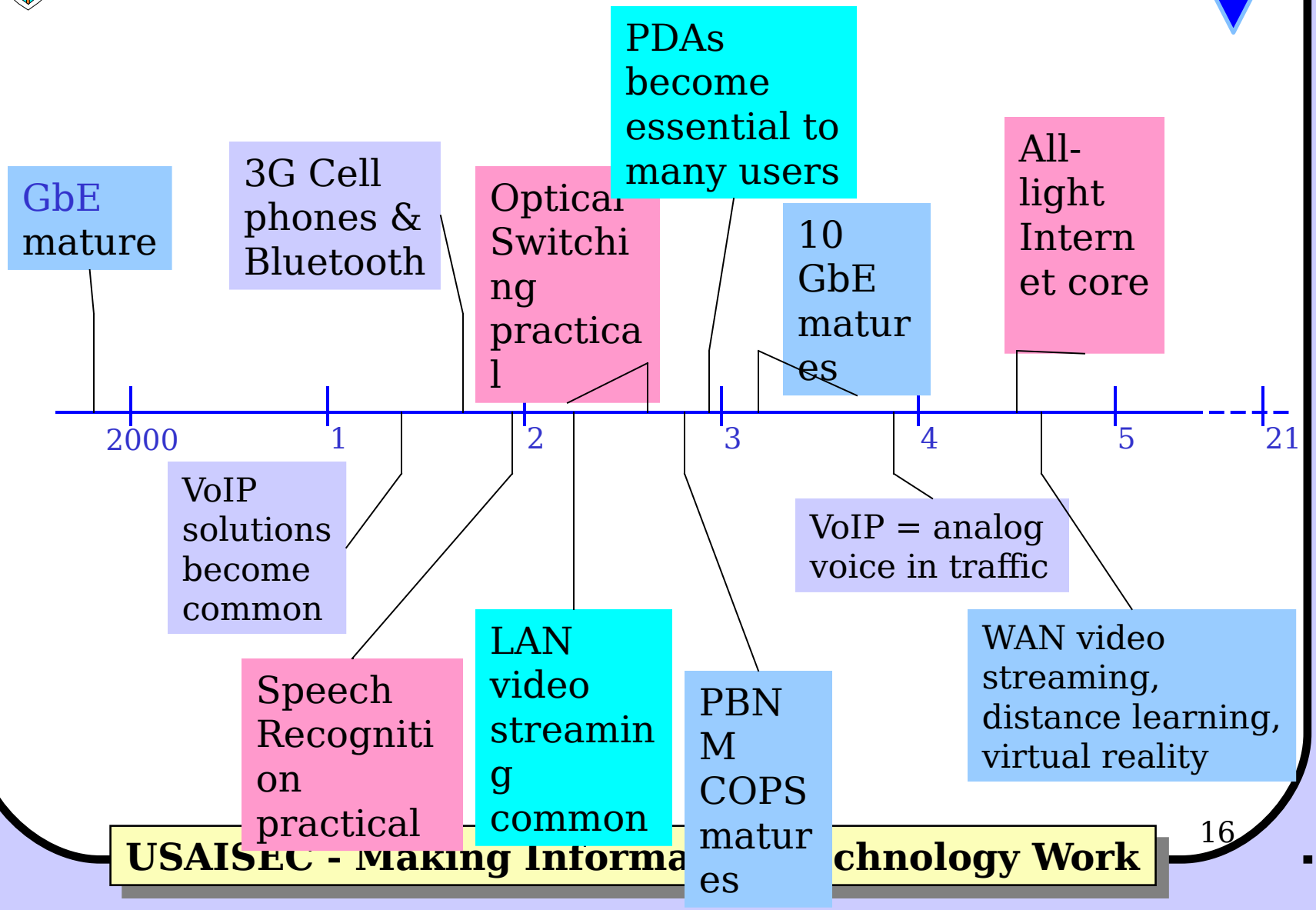
- Parkinson's Law of Bandwidth Absorption *"Network traffic expands to fill the available bandwidth"*
- **Applications no longer hindered by network**
  - Voice over IP for single integrated systems
  - VTC common over WAN to save time, money plus easy collaboration on documents
  - Video Streaming and Distance Learning
  - Virtual Reality Applications
  - Tele-medicine, tele-presence, tele-everything

Obstacles



- Technical Issues
  - Speed of security devices and wireless
- Political
  - These predictions reflect industry momentum
    - Money is the industry's motivation for change
  - DoD's incentive is a little different; DoD sometimes lags industry in implementing new technologies
- Social
  - Humans require time to adapt to technology changes and begin to use tools effectively

Timeline


GbE mature
3G Cell phones & Bluetooth
Optical Switching practical
PDAs become essential to many users
10 GbE matures
All-light Internet core
2000
1
2
3
4
5
21
VoIP solutions become common
Speech Recognition on practical
LAN video streaming common
PBN MCOPS matures
VoIP = analog voice in traffic
WAN video streaming, distance learning, virtual reality

Questions?

References

This presentation is extracted from a white paper which can be downloaded from:

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